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Interim Report

June 6, 2003

John H. Bergman
Fire Chief
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2330 McCulloch Boulevard North
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Dear Chief Bergman:

This interim report is in response to your letter dated May 27, 2003, requesting quick feedback from carbon monoxide (CO) exposure monitoring conducted by NIOSH during the recent Memorial Day weekend. At your request, we measured CO exposures of City police and fire department employees assigned to the London Bridge channel. Your request was for any feedback we could provide that would assist you in making operational decisions to reduce CO among your employees. This letter provides a summary of preliminary data. More time will allow further analysis of the complete body of collected data, which will be the basis of a more comprehensive final report.

Background

This request stemmed from concerns related to past poisonings among visitors to the Lake Havasu London Bridge channel. The Havasu Regional Medical Center had seen four to six patients in the Emergency Department over the past several years who had been poisoned by their exposure to CO while in the channel. These patients had carboxyhemoglobin (COHb) concentrations greater than 30%, indicating severe poisoning. Because these visitors were in areas where Police and Fire Department personnel patrol the waterway for as much as 10 hours per workshift, there was concern that these City employees may be exposed to high levels of CO on holiday weekends when the boat traffic is excessive.

You requested this Memorial Day weekend evaluation as a result of recommendations in the

December 5, 2002 NIOSH report in which preliminary range-finding sampling data from the London Bridge channel were summarized. In that report, the NIOSH investigator made the following recommendations:

1) Full workshift CO exposure monitoring for City employees working in the channel to determine if they are overexposed to CO during high traffic days, and pre- and post-shift exhaled CO measurement accompanied by employee interviews to determine if they experience symptoms of CO overexposure during their duties within the channel. NIOSH, with the assistance of the Mojave County Health Department, assisted the City in carrying out these recommendations during the Memorial Day holiday. This letter summarizes preliminary data from that portion of the resulting interagency project.

2) Further data collection related to visitor CO exposures within the channel, to possibly include measurement of CO in exhaled breath of visitors and/or placement of stationary CO air sampling monitors at fixed locations among the moored boats where visitors linger during high traffic days. The Mojave County Health Department responded to part of this recommendation by requesting that the Arizona Department of Health Services conduct exhaled CO measurements among visitors to the channel during Memorial Day weekend. The City hired a contractor to place stationary CO air sampling monitors and gather additional environmental data in and near the channel through the summer of 2003.

3) Routine measurement of carboxyhemoglogin (COHb) concentrations among Emergency Department patients who have been boating in the channel during high traffic days. NIOSH provided two exhaled breath CO monitors for use by hospital emergency department staff during the Memorial Day weekend.

4) Development of a more comprehensive research and intervention program related to the issue of boat-related CO exposures. The City acted on this recommendation by developing warning signs posted at the channel entry. NIOSH assisted the City and County in obtaining educational brochures for distribution by the City during the Memorial Day weekend, as well.

Four NIOSH personnel were on site to support this multi-faceted study of CO concentrations in the London Bridge channel and related visitor and employee exposures, coordinated by Lake Havasu City. Jane McCammon (NIOSH Denver) worked with City and County representatives and the Emergency Medical Services (EMS) Medical Director from May 19th B May 21st. Subsequently, Kevin Dunn, Rob McCleery, and Dr. Loren Tapp (NIOSH Cincinnati) conducted CO exposure monitoring of City police officers and fire/EMS personnel using breath tests and air sampling for four days (May 23 B 26, 2003) which included the Memorial Day holiday.

Evaluation Criteria and Exposure Health Effects

Detailed information about evaluation criteria and health effects of exposure to CO can be found in Attachments 1 and 2.

Methods

City workers (special unit police officers and fire/EMS workers) who worked in the London Bridge channel area during the Memorial Day weekend (May 23-26, 2003) were asked to participate in the study. Special unit police officers were assigned to work one of the following locations: the East or West bank booking station, the East or West bank police patrol (on either electric-powered or gas-powered golf carts, or gas-powered quads), or on police boats that patrolled the channel. The fire/EMS personnel were assigned to work one of the following locations: the East or West bank (each bank had an EMS station with electric golf carts) or one of the fire boats that responded to emergencies on Lake Havasu, including the London Bridge Channel area.

A total of 40 city workers participated in the personal air monitoring of CO levels (100% participation rate); 36 (90%) participated in the exhaled breath analysis for CO (four workers did not or could not complete one full day of testing and were excluded from the analysis). The CO breath tests were done pre- and post-shift, and were repeated at various times during each worker=s daily shift.

With few exceptions, City employees that participated in the CO breath tests were also provided with data-recording CO exposure monitors to track exposure through the day. Some CO exposure monitors were also placed in stationary locations. Area air samples measuring volatile organic compounds (VOCs), formaldehyde, and acrolein were also collected on one police boat.

Most participants worked 10-hour shifts within the channel during each day of exposure monitoring. On Monday, May 26, 2003, the fire/EMS personnel were not assigned to the channel, and many of the channel-assigned police officers worked a 5- to 6-hour shift because of the greatly reduced number of visitors to the channel that day.

ToxiUltra Atmospheric Monitors (Biometrics, Inc.) with CO sensors were used to measure CO in air and in exhaled breath. All ToxiUltra CO monitors were calibrated before each day=s use according to the manufacturer=s recommendations. These monitors are direct-reading instruments that record data that is then transferred to a computer through an optical interface.

Exhaled breath analysis for CO captures the participant=s exhaled breath in a balloon and

analyzes the sample for CO in parts per million (ppm). This number (CO ppm) is then converted

into an estimate of the % carboxyhemoglobin (COHb) level in the body. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a Biological Exposure Index (BEI) for end of shift exhaled breath analysis in nonsmoking workers (exposed to carbon monoxide) of 3.5% COHb (or 12 ppm). The BEI generally indicates a concentration below which nearly all workers should not experience adverse health effects. The BEI cannot be applied to current smokers since smokers have been shown to have baseline levels between 4 and 20% COHb.

Preliminary Results

Information about weather conditions during the four days of sampling will be provided by the City=s contractor. May 24th and 25th were the busiest days within the channel, with substantial crowds and boat traffic. May 26th was the least crowded; with many of the police officers being sent home early that day.

Results from the VOC, formaldehyde, and acrolein samples will be reported when the results are received from the laboratory.

Exhaled breath analysis for CO

Of the 36 employees who participated in the exhaled breath analysis for CO, 23 were police officers and 13 were fire/EMS personnel. These participants worked from one to four days during the evaluation period of May 23-26, 2003. Seven of the 36 were smokers; three smoked between 1 2 to 2 2 packs of cigarettes per day; four smoked 2 to 5 cigarettes per day. The average age among the 36 participants was 34 years (ranging from 25 to 46). Two reported a history of respiratory disorder. There was one female participant.

Exhaled breath CO measurements were analyzed for the greatest cross-shift difference observed for all participating employees on each day of testing. The cross-shift difference represents the change in % COHb levels from pre-shift to post-shift (or mid-shift, whichever was highest). For example, if the employee=s preshift level was 1.0% COHb and his/her postshift level was 8.0%, then their level increased by 7% COHb. This was done to minimize the effect of smoking and capture the effects of CO exposure from the work environment. To date, there are no specific cross-shift levels of % COHb that have been recommended as criteria or guidelines not to be exceeded. Nevertheless, an increase of 3.5% COHb is an indication that occupational CO over-exposure may be occurring.

The following paragraphs group employees by the date they worked and the cross-shift change

in their % COHb level.

Friday (5/23): 18 total participants - 6 fire/EMS, 12 police

Nine employees (five fire/EMS personnel and four police officers) had an increase in estimated COHb of 0-3.5%

Three employees (all police officers) had an increase in estimated COHb level of >3.5-5%

Six employees (one fire/EMS employee and five police officers) had an increase in estimated COHb level of >5-10%

Saturday (5/24): 24 total participants - 6 fire/EMS, 18 police

Seven employees, one fire/EMS and six police officers, had an increase in estimated COHb of 0-3.5%.

Five employees, one fire/EMS and four police officers, had an increase in estimated COHb level of >3.5-5%.

Twelve employees, four fire/EMS and eight police officers, had an increase in estimated COHb level of >5-10%.

Sunday (5/25): 25 total participants - 7 fire/EMS, 18 police

Twelve employees, six fire/EMS and six police officers, had an increase in estimated COHb level of 0-3.5%.

Four employees, one fire/EMS and three police officers, had an increase in estimated COHb level of >3.5-5%.

Five police officers had an increase in estimated COHb level of >5-10%.

Four police officers (assigned to either a police boat or the West bank) had an increase in estimated COHb level of >10-15%.

Monday (5/26): 14 total participants - all police officers

Thirteen of the police officers had an increase in estimated COHb of 0-3.5%.

One of the police officers had an increase in estimated COHb of >3.5-5%.

Fire/EMS personnel had 7 of 19 (37%) cross-shift exhaled breath measurements show an increase of 3.5% COHb or greater; 5 of these 7 (26% of 19) showed an increase of greater than 5% COHb. Police personnel had 33 of 62 (53%) cross-shift exhaled breath measurements indicate an increase of 3.5% COHb or greater; 22 of these 33 (35% of 62) indicated an increase of greater than 5% COHb. In general, the early mid-shift levels remained fairly low; the levels seemed to increase slowly throughout the day until late afternoon/early evening when the levels began to increase much more rapidly. Although employees with increased % COHb levels were observed in all work assignment locations, the greatest increases appeared to be found in employees working on the boats patrolling the channel and on the West bank. Further analysis of the data is needed to confirm these preliminary results.

To compare exhaled breath CO test results with the ACGIH BEI criteria, we looked at the post-shift estimated % COHb levels in all 29 non-smoking employee participants and grouped them by job title and day of work (Table 1). Of the 63 post-shift exhaled breath CO measurements (reflecting multiple day measurements for some of the 29 non-smoking employees), 42 (67%) were at or above the BEI. This included seven employees (six police officers and one fire/EMS employee) working Friday, May 23rd, nineteen employees (fourteen police officers and five fire/EMS personnel) working Saturday, May 24th, fourteen employees (ten police officers and four fire/EMS personnel) working Sunday, May 25th, and two police officers working Monday, May 26th. No measurements were above 15% COHb.

Table 1: Post-shift % COHb in Nonsmoking City Employees by Job and Date

Day	Job (# at work that day)	# (%)[1] <3.5% COHb	# (%) 3.5- 5% COHb	# (%) > 5 B 10% COHb	# (%) > 10 B 15% COHb
Friday 5/23	Fire/EMS (5)	4 (80%)	0	1 (20%)	0
	Police (6)	0	2 (33%)	4 (67%)	0
	Total Fri. (11)	4 (36%)	2 (18%)	5 (45%)	0
Sat. 5/24	Fire/EMS (5)	0	1 (20%)	4 (80%)	0
	Police (14)	0	4 (29%)	8 (57%)	2 (14%)
	Total Sat. (19)	0	5 (26%)	12 (63%)	2 (11%)
Sun. 5/25	Fire/EMS (7)	3 (43%)	3 (43%)	1 (14%)	0
	Police (14)	4 (29%)	1 (7%)	5 (36%)	4 (29%)
	Total Sun.(21)	7 (33%)	4 (19%)	6 (29%)	4 (19%)
Mon. 5/26	Police (12)	10 (83%)	2 (17%)	0	0
	Total Mon (12)	10 (83%)	2 (17%)	0	0
Totals-all days	# of post-shift analyses (63)	21 (33%)	13 (21%)	23 (37%)	6 (10%)

[1] Number (percentage) of employees in that job category who had % carboxyhemoglobin less than 3.5%

Preliminary Air Sampling Results (Personal Exposures and General Area CO Concentrations)

Friday, May 23rd: Fourteen city employees wore CO monitors during their workshift and 3 CO monitors were placed in fixed locations to measure general area concentrations (one was initially near pump station 3 and was then placed near the DUI van; one was initially used as a exhaled breath monitor and then placed near the DUI van; and one was placed along with the City contractor=s instruments at the restroom that is near pump station 3).

Exposures of 11 of the 14 employees wearing monitors exceeded the NIOSH ceiling limit of 200 ppm at some point during the day.

All employees had peak exposures exceeding the American Conference of Governmental Industrial Hygienists (ACGIH) excursion limit of 125 ppm.

Exposures of 1 employee exceeded and 2 employees approached (within 5 ppm) the

Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 50 ppm as a time-weighted average (TWA);

Exposures of 3 employees exceeded and 3 employees approached the NIOSH Recommended Exposure Limit (REL) of 35 ppm as a TWA;

Exposures of 8 employees exceeded and 2 employees approached the ACGIH Threshold Limit Value (TLV) of 25 ppm as a TWA.

The monitor near the DUI van indicated an average CO concentration of 15 ppm with a peak reading of 188 ppm. The other monitor located near the DUI van indicated an average CO concentration of 20 ppm with a peak reading of 197 ppm. The monitor located at the restroom (collected readings until the morning of May 24th) indicated an average CO concentration of 19 ppm with a peak reading of 437 ppm.

Saturday, May 24th: Twenty-four city employees wore CO monitors during their work shift and two CO monitors were placed in fixed locations to measure general area concentrations (one was located on police boat #1297 and one was near the trailer used by NIOSH personnel on the West side).

All employees wearing monitors exceeded the NIOSH ceiling limit of 200 ppm and the ACGIH excursion limit of 125 ppm at some point during the day.

Exposures of 6 employees exceeded and 3 employees approached the OSHA PEL of 50 ppm as a TWA;

Exposures of 10 employees exceeded and two employees approached the NIOSH REL of 35 ppm as a TWA;

Exposures of 16 employees exceeded and 6 employees approached the ACGIH TLV of 25 ppm as a TWA.

The monitor located on the police boat indicated an average CO concentration of 180 ppm with a peak reading of 1179 ppm. The monitor located near the trailer used by NIOSH personnel indicated an average CO concentration of 17 ppm with a peak reading of 116 ppm.

Sunday, May 25th: Twenty-four city employees wore CO monitors during their work shift and two CO monitors were placed in fixed locations to measure general area concentrations (one

monitor was located on police boat #2196 and one monitor located near the trailer used by

NIOSH personnel on the West side).

Exposures of 18 of the 24 employees wearing monitors exceeded the NIOSH ceiling limit of 200 ppm at some point during the day.

Twenty-two of the 24 employees had peak exposures exceeding the ACGIH excursion limit of 125 ppm.

Exposures of 3 employees exceeded the OSHA PEL of 50 ppm as a TWA;

Exposures of 6 employees exceeded and 3 employees approached the NIOSH REL of 35 ppm as a TWA;

Exposures of 11 employees exceeded and 1 employee approached the ACGIH TLV of 25 ppm.

The monitor located on the police boat indicated an average CO concentration of 111 ppm with a peak reading of 1053 ppm. The GA monitor located near the trailer used by NIOSH personnel indicated an average CO concentration of 12 ppm with a peak reading of 135 ppm.

Monday, May 26th: 15 city employees wore CO monitors during their workshift and two CO monitors were placed in fixed locations to measure general area concentrations (one monitor was located near the Eastside booking station and one was located near the Westside booking station). The duration of exposure monitoring for all employees was less than 8 hours due in part to employees being released from work early.

One of the 15 employees wearing monitors exceeded the NIOSH ceiling limit of 200 ppm at some point during the day.

Four of 15 employees had peak exposures exceeding the ACGIH excursion limit of 125 ppm.

No employee exposures on this day exceeded the OSHA PEL of 50 ppm, the NIOSH REL of 35 ppm, or the ACGIH TLV of 25 ppm (all TWA limits).

The monitor located at the Eastside booking station indicated an average CO concentration of 22 ppm with a peak reading of 75 ppm. The monitor located at the Westside booking station indicated an average CO concentration of 24 ppm with a peak reading of 137 ppm.

Conclusions

Air-sampling and breath tests results indicate many City employees were over-exposed to CO

when working extended shifts in the channel during the Memorial Day weekend; this was true whether they were working on a boat or assigned to gas- or electric-powered vehicles on the East or West banks. Exhaled breath tests for CO indicated that a high percentage of the employees= post-shift estimated % COHb levels were at or above the BEI (3.5%), indicating that these employees were being exposed to CO concentrations that may cause adverse health effects. Several employees were exposed to CO concentrations in excess of legal and recommended limits for short- and long-duration exposure.

Because employees on both gas- and electric-powered carts and quads experienced elevated estimated COHb levels, the carts and quads themselves appeared to have insufficient impact on the employees= exposures.

Because employee exposure circumstances differ greatly from those of visitors, the City should exercise caution in viewing these data as indicative of possible visitor exposure. Visitors standing submerged to their shoulders or neck for long periods of time, placing their breathing zone very near the exhaust of the passing boats, and visitors sitting on the transom or swim platform of moving boats may be exposed to much higher CO concentrations than employees.

Preliminary Recommendations

The recommendations below are intended to reduce the health hazard for employees.

1. The City should determine what actions to take to bring about a reduction of overall CO concentrations within the channel area during high boat-traffic days, thus reducing the potential for employee over-exposure. Reducing the number of boats with operating engines is likely to be the only way to achieve a reduction in CO concentrations. Any action taken will have to be coordinated among law enforcement groups with jurisdiction in this waterway. Several ideas to accomplish this reduction discussed by the study group include: implementing the use of docking meters to reduce the amount of time spent in the channel by individual boats; changing the pattern of movement of boats in the channel (i.e., one-way boating traffic); monitoring the number of boats traveling through the channel and limiting further boat entry when a maximum number is reached; etc.

2. Employees assigned to duty within the channel or on boats elsewhere should receive training about the health effects of CO, and work-practices that can reduce exposure to vehicle and boat exhaust. Examples of such work-practice instructions include such things as: deactivating boat

propulsion engines while making an arrest; asking others to deactivate their propulsion engines and/or generator when employee boats are rafted during an arrest or other enforcement activity; staying away from the back of the boat as much as possible when propulsion engines are

operating; and/or prohibiting sitting on the transom or any rear platform while the engines are

operating.

3. The City should develop an employee exposure monitoring program to determine patterns of overexposure for employees (i.e., are they overexposed only on warm-weather holiday weekends, or at other times or during certain job tasks as well) and to ensure that control measures such as assignment rotation, or reduction of CO concentrations within the channel, are effective.

4. Until CO concentrations are reduced within the channel, the City should periodically rotate employee assignments to areas where CO exposure does not occur, particularly in the late afternoon and early evening hours when CO concentrations seem to elevate in the channel. An exposure monitoring program (as mentioned in Recommendation 3) would provide further data for use in determining if such rotation in scheduling is needed only on high traffic dates or on a more regular basis.

5. Employees should be encouraged to report symptoms of CO poisoning to designated health and safety personnel and should be provided with appropriate medical evaluation of symptoms.

We appreciate the chance to work with you on this important project. Please call Jane McCammon if you have any questions about information contained in this letter. A final report with more complete data analysis will follow this preliminary report within two months.
Sincerely,

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Cc: Richard Hartle, NIOSH Cincinnati

Attachments

Attachment 1
Health Effects of Exposure to Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing materials such as gasoline or propane fuel. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, or nausea. Symptoms may advance to vomiting, loss of consciousness, and collapse if prolonged or high exposures are encountered. If the exposure level is high, loss of consciousness may occur without other symptoms. Coma or death may occur if high exposures continue.[1-6] The display of symptoms varies widely from individual to individual, and may occur sooner in susceptible individuals such as young or aged people, people with preexisting lung or heart disease, or those living at high altitudes.

Exposure to CO limits the ability of the blood to carry oxygen to the tissues by binding with the hemoglobin to form carboxyhemoglobin (COHb). Once exposed, the body compensates for the reduced blood borne oxygen by increasing cardiac output, thereby increasing blood flow to specific oxygen-demanding organs such as the brain and heart. This ability may be limited by preexisting heart or lung diseases that inhibit increased cardiac output.

Blood has an estimated 210-250 times greater affinity for CO than oxygen, thus the presence of CO in the blood can interfere with oxygen uptake and delivery to the body. Once absorbed into the bloodstream, the half-time of CO disappearance from blood (referred to as the Ahalf-life@) varies widely by individual and circumstance (i.e., removal from exposure, initial COHb concentration, partial pressure of oxygen after exposure, etc.). Under normal recovery conditions breathing ambient air, the half-life can be expected to range from 2 to 6.5 hours.[7] This means that if the initial COHb level were 10%, it could be expected to drop to 5% in 2 or more hours, and then 2.5% in another 2 or more hours. If oxygen is administered to the exposed person, as happens in emergency treatment, the half-life time is decreased again by as much as 75% (or to as low as approximately 40 minutes). Delivery of oxygen under pressure (hyperbaric treatment) reduces the half-life to approximately 20 minutes.

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Attachment 2
Evaluation Criteria

Occupational criteria for CO exposure are applicable to employees who may be at risk of CO poisoning. The occupational exposure limits noted below should not be used for interpreting general population exposures (such as visitors engaged in boating activities) because occupational standards do not provide the same degree of protection they do for the healthy worker population. The effects of CO are more pronounced in a shorter time if the person is physically active, very young, very old, or has preexisting health conditions such as lung or heart disease. Persons at extremes of age and persons with underlying health conditions may have marked symptoms and may suffer serious complications at lower levels of carboxyhemoglobin.[1] Standards relevant to the general population take these factors into consideration, and are listed following the occupational criteria.

Occupational Exposure Criteria. As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, or a pre-existing medical condition. In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists= (ACGIH7) Threshold Limit Values (TLVs7), [3] (3) the legal requirements of the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs),[4] and (4) the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard for ventilation for acceptable indoor air quality.[5] Employers are encouraged to follow the more protective criterion listed.

A TWA exposure refers to the average airborne concentration of a substance during a

normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

The NIOSH REL for CO is 35 ppm for full shift TWA exposure, with a ceiling limit of 200 ppm which should never be exceeded.[6,7] The NIOSH REL of 35 ppm is designed to protect workers from health effects associated with COHb levels in excess of 5%.[1] NIOSH has established the immediately dangerous to life and health (IDLH) value for CO as 1,200 ppm.[8] An IDLH value is defined as a concentration at which an immediate or delayed threat to life exists or that would interfere with an individual's ability to escape unaided from a space.

The ACGIH recommends an eight-hour TWA TLV of 25 ppm based upon limiting shifts in COHb levels to less than 3.5%, thus minimizing adverse neurobehavioral changes such as headache, dizziness, etc, and to maintain cardiovascular exercise capacity.[9] ACGIH also recommends that exposures never exceed 5 times the TLV (thus, never to exceed 125 ppm).

The OSHA PEL for CO is 50 ppm for an 8-hour TWA exposure.[10]

Health Criteria Relevant to the General Public.
The US EPA has promulgated a National Ambient Air Quality Standard (NAAQS) for CO. This standard requires that ambient air contain no more than 9 ppm CO for an 8-hour TWA, and 35 ppm for a one-hour average.[11] The NAAQs for CO was established to protect Athe most sensitive members of the general population@ by maintaining increases in carboxyhemoglobin to less than 2.1%.

The World Health Organization (WHO) had recommended guideline values and periods of time-weighted average exposures related to CO exposure in the general population.[12] WHO guidelines are intended to ensure that carboxyhemoglobin levels not exceed 2.5% when a normal subject engages in light or moderate exercise. Those guidelines are:

100 mg/m^3 (87 ppm) for 15 minutes
60 mg/m^3 (52 ppm) for 30 minutes
30 mg/m^3 (26 ppm) for 1 hour
10 mg/m^3 (9 ppm) for 8 hours

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